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AUTHOR	Kincaid, J. Peter; And Others
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ABSTRACT

The computer readability editing system described in this report was developed to serve as an author's aid in improving the ease of comprehending Navy technical manuals and training materials. The system has features to (1) flag uncommon and misspelled words and long sentences, (2) suggest simple replacements for difficult words and phrases, and (3) calculate the readability grade level. Each feature was tested to verify that it provides useful feedback to editors and authors. Written in Wang BASIC-2, the program can be run on computer equipment costing about $25,000. Twelve references are listed. (Author/LLS)

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COMPUTER READABILITY EDITING SYSTEM

J. Peter Kincaid
James A. Aagard
Training Analysis and Evaluation Group

John W. O'Hara
Navy Personnel Research and Development Center

Larry K. Cottrell
University of Central Florida

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Training Analysis and Evaluation Group
Orlando, Florida 32813

Computer Readability Editing System

J. PETER KINCAID, JAMES A. AAGARD, JOHN W. O'HARA, AND LARRY K. COTTRELL

Abstract—**A computer readability editing system was developed to serve as an author's aid in improving the ease of comprehending technical manuals and training materials. The system has features to (1) flag uncommon and misspelled words and long sentences, (2) suggest simple replacements for difficult words and phrases, and (3) calculate the readability grade level. Each feature was tested to verify that it provides useful feedback to editors and authors. The program is written in Wang BASIC-2 and can be run on computer equipment costing about $25,000.**

THE U.S. military services and American companies produce a vast quantity of technical information each year in the form of both technical manuals and training materials. The U.S. Navy alone is estimated to have an inventory of nearly 40 million pages of technical information to support its ships and other equipment. Traditionally, this material has been difficult to use, even by skilled technicians, and this problem has been compounded by a decline in reading ability over the last decade in this country. Thus, a readability problem exists. The problem is clearly recognized by all of the U.S. military services who have established remedial reading programs for enlisted personnel with deficient reading skills [1].

The use of computers for the production of technical information is increasing rapidly. Computers are now routinely used for such functions as typesetting, formatting, and to check spelling. Most large companies which produce technical information under contract to the U.S. military services and many military publishing centers now use computerized word processing equipment [2]. In a related development, programs for performing computerized readability analyses are also coming into use [3]. These programs calculate a number of formulas including those based on familiar word lists such as the Dale-Chall Formula [4]. General Motors Corporation has developed the STAR computer program which calculates the most widely used readability measurement, the Flesch Reading Ease Formula [5].

The widespread use of computerized readability analyses in computer-based publishing centers appears likely. They can have particular value in producing easier to comprehend technical information if they are designed as a tool to give writers specific and immediate suggestions.

With these considerations in mind, the computer readability editing system (CRES) was designed. The system accepts written narrative material, evaluates that material for readability, and suggests editorial changes in content (words) based on stored lists of words which have been developed to reduce the difficulty of reading material. While the system was designed for use with military technical materials, minor changes in the word lists would make the system appropriate for use with a wide variety of other technical materials.

FEATURES OF THE SYSTEM

Readability Formula

A readability formula provides a measure of the reading difficulty of a sample of text. The Flesch-Kincaid Readability Formula [6] is used in the system because it is the Department of Defense readability standard [7]. This formula provides a readability grade level of the sample text which refers to the average reading ability of those who should be able to understand the text. It is a recalculation of the Flesch Reading Ease Formula developed by testing Navy enlisted personnel on their understanding of passages from Navy training manuals. The Flesch-Kincaid formula is

$$\textit{Grade Level} = 0.39\ (\textit{Avg. No. Words/Sentence}) + 11.8\ (\textit{Avg. No. Syllables/Word}) - 15.59.$$

The computer program that calculates this formula is adapted from the General Motors STAR program which was originally designed to calculate the Flesch Reading Ease Formula. The program counts the number of syllables, words, and sentences in a passage of text, then computes the above formula. The readability grade level thus calculated by the editing system serves as a general guide to the writer concerning the appropriateness of the material for the intended readers. If the grade level is too high, the text should be simplified.

Readability formulas provide only a general indication of the overall level of difficulty. The other components of CRES provide more specific feedback to writers about particular words and sentences.

Common Word List

The Common Word List was developed to identify uncommon words and is similiar in concept to other familiar word lists. (If a word is not on the Common Word List it is presumed to be uncommon.) The Dale-Chall list [4] was developed for use with elementary school reading materials, and a variety of "controlled English" lists are useful for writing technical

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J. P. Kincaid is a Psychologist in charge of the Readability Project for the U.S. Navy Training Analysis and Evaluation Group, Orlando, FL; J. A. Aagard is a Psychologist with the same organization. J. W. O'Hara is a Psychologist with the Navy Personnel Research and Development Center, San Diego, CA. L. K. Cottrell is Assistant Professor of Computer Science, University of Central Florida, Orlando, and Consultant to the U.S. Navy Training Analysis and Evaluation Group. Address correspondence to J. P. Kincaid, TAEG, Orlando, FL 32813, (305) 646-5673.

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documents for worldwide distribution [8]. If a word is flagged as uncommon, a decision must be made whether to retain it, replace it with a simpler word, or define it. This decision is subjective and must be made by the author or editor, not by the computer.

Simplifying the words used in training and technical manual texts will result in instructional material that is more easily read and understood by the trainee and the technician. The Common Word List is a merged list of 4,300 root words made up of three military word lists, two published word lists [9, 10], and one list of Navy-specific words. About 1,900 words common in Navy documents were identified by a computer frequency analysis of 240,000 words taken from two basic Navy training texts used in recruit training [11, 12]. The Common Word List (as well as the other word lists) has been designed to be easily modified. Publishing groups who adopt this system should expect to make changes in the lists to include words common in their own particular literature.

Supplementary Technical Word Lists

Although the Common Word List should contain most words in general Navy reading material, it does not contain many technical terms used in specialized reading material. Therefore, it was necessary to construct supplemental lists for use with certain kinds of specialized material.

The technical supplementary lists contain terms that are frequently used and commonly known by technical specialists but not by nonspecialists. For example, an electronics technician would certainly know the meaning of *capacitance* whereas a nonspecialist might not. These supplemental lists are a necessary part of the system for the editing of text dealing with technical specialties, otherwise the system would flag words like *capacitance* appearing in electronics training materials. Three lists were constructed—electronics, engineering, and clerical. The final lists, each consisting of 100 to 200 words, were compiled by subject matter experts who narrowed down a list compiled from two sources: (1) the most frequently occurring words in appropriate Navy technical materials, and (2) glossaries from appropriate military training courses.

Substitution Lists

A substitution feature facilitates replacement of awkward words or phrases with simpler or more specific ones. Once undesirable words are identified and substitutes offered, the writer makes the decision whether to replace the word with one of its proposed substitutes. Two existing substitution lists were adapted for use in the system, one used by U.S. Army Headquarters for writing policy directives and the other, a preferred verb list for U.S. Navy procedural manuals.

TEST OF SYSTEM FEATURES

Each feature of the system was tested using carefully chosen samples of text representative of a wide variety of Navy training materials and technical manuals. Altogether more than 10,000 words of text, representative of essential reading material encountered by Navy enlisted personnel, constituted the test passages.

The readability formula was the first feature of the system to be programmed for the computer and tested. The Flesch-Kincaid formula is based on the number of sentences, number of words, and number of syllables in the text sample being analyzed. An accurate manual count had been made of each of 18 test passages. Agreement between the manual and computer counts was nearly perfect. Correlation coefficients for each of the pairs of these three factors were above 0.99.

Evaluation of the Common Word List and the supplemental technical lists was basically a subjective process. It consisted of judging whether words flagged as uncommon did, in fact, appear to be uncommon. Each passage in the test was analyzed using the Common Word List. Words not on the Common Word List were printed at the bottom of each analyzed passage. As a result of a subjective judgment it was concluded that the Common Word List was sufficiently complete for most purposes. It was judged that fewer than one percent of the words in the test passages were inappropriately flagged as uncommon.

The word substitution lists required a more thorough evaluation than other features of the system because each substitution made in the computer analysis of the test passages had to be judged independently. Between 70 and 80 percent of the substitutes were judged to be simpler or more specific than the words or phrases they replaced.

USE OF THE SYSTEM

The system is designed to be part of a computer-based publishing system. It is most useful to contractors and military writing centers who must write training materials and technical manuals with controlled vocabularies and low levels of readability (below the 8th grade).

The steps for using the system (see Fig. 1) are

- Choose program options.
- Author or typist enters text (typically 500 to 2,000 words).
- Text is analyzed and printed out and shown on the display.
- Author revises text prompted by computer-generated suggestions (see Fig. 2).
- Revisions are entered and stored.
- Revised text is again analyzed to obtain readability grade level and check for keying errors.
- Editor approves text which is then stored for final camera-ready printout (for example, using a daisy wheel printer).

Text to be analyzed by the program is entered by the operator either manually by keyboarding or automatically if the text is in machine-readable form. No special symbol is required as a delimiter for words, phrases, or sentences; the tasks of entering and modifying the text can be completed by those who have no special skill except typing. Text files can be of any length.

Analysis of a test passage is done on a word-by-word basis. Each word, except for the last word of a sentence, is viewed as the possible beginning of a phrase; hence, the phrase analysis is completed first by the program. If it is determined that the word is not the beginning of a phrase, a search for the occur-

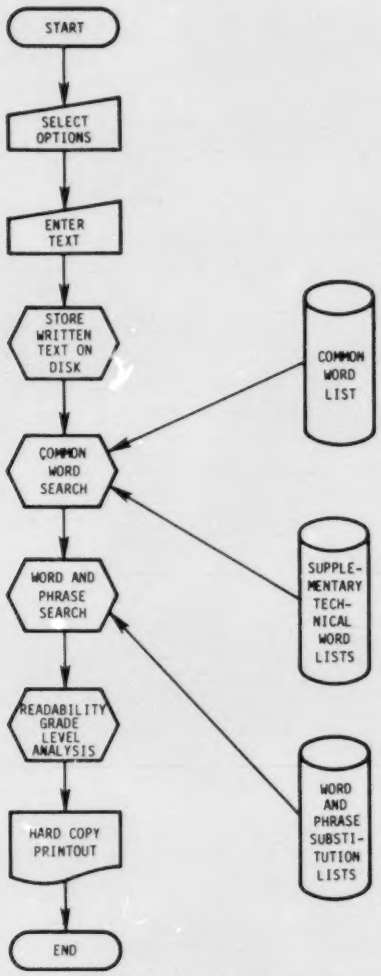
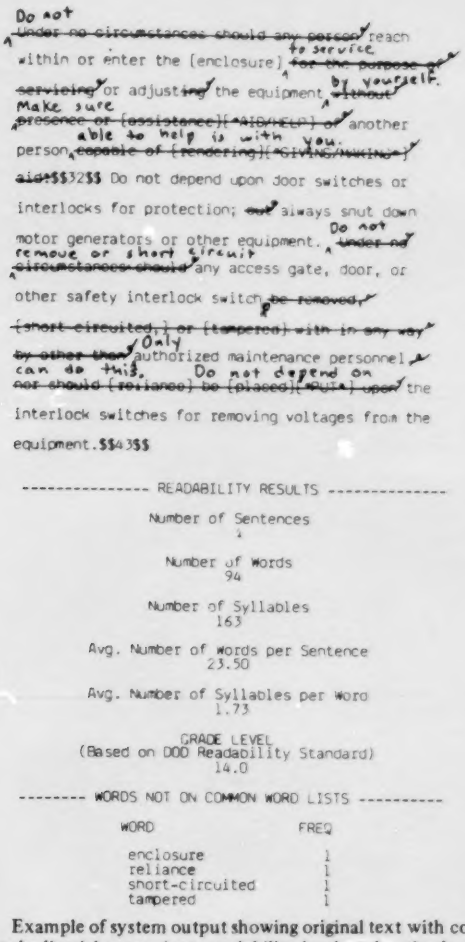


Fig. 1. Flowchart showing phases of editing by the computer readability editing system.



Do not
~~Under no circumstances should any person~~ reach within or enter the [enclosure] ~~for the purpose of servicing~~ or adjusting the equipment ~~without~~ by yourself. Make sure ~~presence of [assistance][HIMSELF]~~ of another person ~~capable of [rendering][GIVING/having]~~ aid.$$32$$ Do not depend upon door switches or interlocks for protection; ~~but~~ always shut down motor generators or other equipment. Do not ~~remove or short circuit any access gate, door, or other safety interlock switch be removed, [short circuited,] or [tampered] with in any way by other than~~ Only authorized maintenance personnel can do this. Do not depend on ~~nor should [reliance] be [placed][PUT] upon~~ the interlock switches for removing voltages from the equipment.$$43$$

---------- READABILITY RESULTS ----------

Number of Sentences
1

Number of Words
94

Number of Syllables
163

Avg. Number of Words per Sentence
23.50

Avg. Number of Syllables per Word
1.73

GRADE LEVEL
(Based on DOD Readability Standard)
14.0

-------- WORDS NOT ON COMMON WORD LISTS ----------

WORD	FREQ
enclosure	1
reliance	1
short-circuited	1
tampered	1

Fig. 2. Example of system output showing original text with computer-generated editorial suggestions, readability level, and author's changes.

rence of that word in one of the word lists is conducted. If the word is not found in a word list, it is placed on the uncommon word list that is printed at the end of the text analysis.

Several word lists are searched. The first is an in-core-memory list of 148 "most" common words taken from the Navy-specific word list. These 148 words account for about 50 percent of word usage in the 240,000-word sample of recruit training texts.

If the search does not find the word on the "most" common list of words, the program searches the Common Word List (4300 words) and the supplementary technical word lists (a few hundred words). If the word is not found in any of these lists, the word/phrase substitution list is searched. Since there are more than 12,000 words in this list, it is not possible to place these in core memory, so a disk file must be accessed.

Fig. 2 is a computer printout illustrating the use of the computer readability editing system. It contains the text of a safety warning, written at a college level of readability and intended for non-U.S. technicians who read English at the eighth grade level, and computer-generated suggestions for improvement; also shown are the author's handwritten changes. These changes are based on judgment as well as the computer-generated suggestions.

This printout illustrates features of the editing system which

- Flab uncommon words—those not on the Common Word List or supplementary technical word lists being used (these are shown in square brackets).
- Flab long sentences—those over 22 words, giving the number or words in the long sentences (shown between dollar signs).
- Suggest replacements for awkward words and phrases (shown between asterisks).
- Provide the readability grade level according to the Department of Defense standard, Flesch-Kincaid formula.

In addition, the system flags misspelled words if they are not on the Common Word List or any supplementary technical word list being used.

The text of the safety warning revised as indicated in Fig. 2, is at a readability grade level of 8, compared to level 14 for the original text.

FUTURE ENHANCEMENTS OF THE SYSTEM

Several enhancements to the current system are being considered to improve both the operation of the system and analyses of textual data. The rate of analyzing the text depends heavily upon the number of disk accesses that must be made to determine whether the word or phrase being analyzed is contained in the stored lists. A noticeable improvement was first made by placing the "most" common words in central memory. It is not possible, however, to place all words from all lists into the central memory of the computer due to the number of words on each list. Currently, a hashing algorithm is being developed to reduce the average number of disk accesses per word of text when a disk-file search is required.

Another improvement in the use of the system is the development of an on-line editing capability. At present, the computer-analyzed text is routed directly to the printer (see Fig. 1), prohibiting any on-line editing. A feature is being added to the system which will write the analyzed text to a disk file and then permit the author to edit the analyzed text at a CRT work station.

Other features of the system that are planned are the flagging of passive-voice expressions (e.g., "the ball was thrown by John") and multiple negatives within a sentence.

APPENDIX

Software

All software for the computer readability editing system is written in the Wang BASIC-2 programming language. This is an extension of the BASIC programming language developed at Dartmouth. BASIC-2 is a powerful language and potential users who are considering installing the computer readability editing system on hardware other than Wang must be prepared to change certain program statements.

Hardware

The computer readability editing system is being developed and implemented of a Wang 2200 MVP Computer System. The hardware components include a CRT with keyboard, the central processing unit (CPU), mass storage devices (disks and tapes), and a printer for hard-copy output. The specific hardware used includes

- Wang 2236D CRT for entry and display,
- Wang 2200 MVP CPU,
- Wang 2200 compatible printer, and 13.4-megabyte disk platter and compatible disk drive.

Supplementary hardware available for maintenance and transportability of the computer readability editing system includes an eight-inch floppy diskette drive and an 800-bpi nine-track tape drive.

The system was designed to operate using a 64-kilobyte central memory because this is a common size. However, this memory limitation required special techniques in developing the program.

All software (programs) and data (word lists) reside on a 13.4-megabyte platter of the disk drive. Fifty-six kilobytes of central memory of the CPU are allocated for operation of the system. The 2236D CRT contains a maximum of 24 rows by 80 columns for a total of 1,920 characters.

Excluding the tape drive, the current cost of the hardware is about $25,000.

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